

**[001] METHODS AND SYSTEMS FOR FABRICATING COMPOSITE
STRUCTURES INCLUDING FLOOR AND ROOF STRUCTURES**

5 **[002] TECHNICAL FIELD**

[003] The present invention relates to methods and systems for fabricating composite structures, including floor and roof structures.

10 **[004] BACKGROUND OF THE INVENTION**

[005] It is known to use reinforced concrete to build various structures. Reinforced concrete is used for example in pre-fabricated and monolithic slabs for floor and roof structures. Ribbed reinforced concrete floor and roof structures are the most 15 structurally effective. However, the known methods of construction of floor and roof slab, particularly pre-fabricated ribbed structures are relatively complex. Accordingly the costs are relatively high due to the relatively high costs for making such slabs, and the expensive delivery and crane involvement needed for the unloading and installation at the construction site. Erection of the monolithic ribbed reinforced 20 concrete floor system with stay-in-place or removable formwork is also very expensive due to high labor costs for the formwork construction and shoring (vertical propping) and if removable formwork, its disassembly afterwards.

[006] To avoid these disadvantages, the ribbed reinforced concrete floor systems are 25 more often used for the monolithic structures with additional elements to form composite structures. Another fabricated element, such as a truss, a girder or steel or aluminum beam is used to provide the designed structural stability and strength to handle the loads during the erection of the reinforced concrete floor and roof structures. These beams are anchored in the reinforced concrete floor integrating them 30 into the ribbed floor system to serve as ribs, but require special devices to provide appropriate anchoring in the standard beams.

[007] For such reinforced concrete floor system, it is known to utilize a stay-in-place formwork from the rigid foam plastic materials, in particular, foamed polystyrene.

Thus, such reinforced concrete floor system provides the compliance with the other design requirements, such as thermal and acoustic insulation properties. However, due

5 to insufficient strength of the foamed polystyrene, this stay-in-place formwork requires the construction of supporting structures and their disassembly after unhardened concrete pouring and concrete hardening, which is a highly time-consuming procedure.

10 [008] Also, known reinforced concrete composite floor structures require the installation of longitudinal and transverse reinforcement bars and their proper positioning in the slab, which is a highly time-consuming and requires skilled laborers and engineer's supervision during installation of the reinforcement prior to the concrete being poured. This increases the overall cost of the construction.

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[009] Therefore, the known systems and methods are relatively inefficient, expensive and therefore it is desired to provide improved methods and systems.

[010] SUMMARY OF THE INVENTION

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[011] According to one aspect of the present invention, there is provided a system for fabricating a slab from a construction material having both unhardened and hardened states. The system is comprised of a form panel unit and a pair of spaced structural supporting members adapted for assisting in supporting the slab made with the construction material. The form panel unit is comprised of a panel member, which generally has opposed upper and lower surfaces, adapted for use as part of a form to retain the construction material when in an unhardened state and at least one reinforcement unit which has at least one reinforcement member mounted above the upper surface of the panel member and is interconnected to the panel member. The form panel unit is configured such that the panel member can be positioned between the spaced structural supporting members, such that the unhardened construction material can be retained above upper surface of the panel member to permit hardening of the construction material from the unhardened state to the hardened state. The

reinforcement member has a portion being mounted on at least one of the supporting members such that the panel member is at least in part suspended from the at least one supporting member, and wherein the at least one supporting member has an upper portion extending above the upper surface of the panel member so it can be embedded
5 in the construction material.

[012] According to another aspect of the present invention, there is provided a system for fabricating a slab from a construction material having both hardened and hardened states. The system is comprised of first and second form panel units and
10 first, second and third spaced structural supporting members adapted for assisting in supporting the slab made from the construction material. Each of the first and second form panel units is comprised of a panel member, which has generally opposed upper and lower surfaces, adapted for use as part of a form to retain the construction material when in an unhardened state and at least one reinforcement unit each having
15 at least one reinforcement member mounted above the upper surface of the panel member. The first form panel unit is configured such that the panel member of the first form panel unit is positioned between the first and second spaced structural supporting members. The reinforcement member of the reinforcement unit of the first form panel unit is supported at least in part by the first and second supporting
20 members such that the panel member of the first form panel unit is suspended from the first and second supporting members on the reinforcement member above the upper surface. The second form panel unit is configured such that the panel member of the second form panel unit can be positioned between the second and third spaced structural supporting members. The reinforcement member is supported at least in
25 part by the second and third supporting members such that the panel member of the second form panel unit is suspended from the second and third supporting members on the reinforcement member of the second reinforcement unit above the upper surface of the panel member of the second form panel unit. Wherein the unhardened construction material can be retained above the panel members of the first and second form panel units between the first and third structural supporting members to permit
30 hardening from the unhardened state to the hardened state of the construction material.

[013] According to another aspect of the present invention, there is provided a structural slab comprised a construction material; a form panel unit; and, first and second spaced structural supporting members adapted to assist in supporting the slab made from the construction material. The form panel unit is comprised of a panel member which has an upper surface and forms at least part of a form. At least one reinforcement unit has at least one reinforcement member mounted to the panel member above the upper surface of the panel member. The panel member is suspended from the first and second supporting members on the reinforcement member. The construction material envelops at least an upper portion of the supporting members and the reinforcement member.

[014] According to another aspect of the invention, there is provided a method for fabricating a slab from a construction material having both hardened and unhardened states using a formwork system. The formwork system is comprised of a form panel unit and first and second structural members adapted to assist in supporting the slab made from the construction material. The form panel unit is comprised of a panel member, which generally has opposed upper and lower surfaces, adapted for use as a form to retain the construction material in an unhardened state and at least one reinforcement unit each having at least one reinforcement member mounted to the panel member above the upper surface. The method comprises the steps of (i) arranging the first and second structural support members in a spaced relation suitable for supporting the panel member; and, (ii) positioning the reinforcement unit such that the panel member is suspended from the first and second spaced structural supporting members, such that the unhardened construction material can be retained above the panel member to permit hardening from the unhardened state to the hardened state of the construction material, and such that the reinforcement member is supported at least in part by the supporting members and the panel member is suspended from the supporting members on the reinforcement member above the upper surface.

[015] According to another aspect of the present invention, there is provided a system for fabricating a slab from a construction material having both unhardened and hardened states. The system comprises a form panel unit and a pair of spaced structural supporting members adapted for supporting the slab made from the

construction material. The form panel unit is comprised of first and second panel members, each adapted for use as a form to retain the construction material when in a unhardened state. Each first and second panel members have generally opposed inner and outer surfaces, and opposed first and second side surfaces. The first and second
5 panel members are arranged in spaced, generally aligned relation with the inner surface of the first panel arranged in face to face relation with the inner surface of the second panel. At least one reinforcement unit has at least one reinforcement member mounted to both of the first and second panel member between the inner surfaces of the first and second panels, the reinforcement member extending beyond at least one
10 of the first and second side surfaces of the first panel member. The form panel unit is configured such that the first panel member can be positioned between the spaced structural supporting members, such that the liquid construction material can be retained between the first and second panel members, between the structural supporting members to permit hardening from the liquid state to the hardened state of
15 the construction material. The reinforcement member is supported at least in part by the supporting members such that the first panel member is suspended from the supporting members on the reinforcement member.

[016] According to another aspect of the invention, there is provided a method for
20 fabricating a slab from a construction material having both hardened and unhardened states using a formwork system. The formwork system is comprised of a form panel unit and first and second supporting members adapted to assist in supporting the slab made from the construction material. The form panel unit is comprised of a panel member, which generally has opposed upper and lower surfaces and opposed first and
25 second side surfaces, adapted for use as a form to retain said construction material when in a liquid state and at least one reinforcement unit each having at least one reinforcement member mounted to the panel member above the upper surface. The method comprises the steps of: (1) arranging the first and second structural support members in a spaced relation suitable for receiving the panel member therebetween;
30 and, (2) suspending the panel member between the pair of supporting members on the reinforcement member, such that the panel member is located between the first and second spaced structural supporting members and the unhardened construction material can be retained above the panel member.

[017] According to another aspect of the present invention, there is provided a formwork assembly for fabricating a slab from a construction material having both unhardened and hardened states. The formwork assembly is comprised a form panel unit and a pair of supporting members adapted for assisting in supporting the slab made from the construction material. The form panel unit is comprised of a panel member having generally opposed upper and lower surfaces and a pair of supporting members adapted for assisting in supporting the slab made from the construction material. The panel member is adapted to be used as part of a form to retain the construction material above the upper surface when in an unhardened state. A reinforcement unit having at least one reinforcement member mounted above the upper surface of the panel member. The panel member is suspended between the pair of supporting members on the reinforcement member, such that the unhardened construction material can be retained above the panel member.

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[018] According to another aspect of the present invention, there is provided a structural elongated support member for use in supporting a concrete slab. The support member has an upstanding web which has an upper elongated web portion. The upper web portion has a plurality of spaced apertures disposed along the elongated upper web portion.

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[019] BRIEF DESCRIPTION OF THE DRAWINGS

[020] In drawings that illustrate by way of example only, preferred embodiments of the present invention:

[021] Figure 1 is a top perspective view of a form panel unit in accordance with an embodiment of the invention;

[022] Figure 1a is a top perspective view of one of the several reinforcement units that are part of the form panel unit of Figure 1;

[023] Figure 1b is a top perspective of a pair of supporting beam members;

[024] Figures 2 and 2a are fragmented transverse cross sectional views showing the mounting of a form panel unit of Figure 1 onto the supporting beam members of Figures 1b which have an opening therebetween;

[025] Figure 2b is an enlarged detailed fragmented transverse cross-sectional view 5 of the connection between two adjacent form panel units of Figures 2 and 2a, each supported at one end by a common supporting beam member;

[026] Figure 2c is a fragmented longitudinal cross-sectional view at 2c-2c in Figure 2b;

[027] Figure 3 is an fragmented transverse cross-sectional view of a floor/ceiling 10 system employing several of the form panel units of Figure 1 in a ceiling and floor structure with several supporting beam members embedded into the reinforced concrete floor slabs and connected with ceiling structures;

[028] Figure 4 is top perspective view of an alternate embodiment of a form panel unit;

[029] Figure 4a is a top perspective view of one of the alternate reinforcement unit 15 to the reinforcement unit of Figure 1a, as used in the form panel unit of Figure 4;

[030] Figure 4b is a fragmented transverse cross-sectional view illustrating the use of the form panel units of Figure 4 supported by beams with an opening and illustrating the connection between adjacent form panel units;

[031] Figure 4c is a fragmented longitudinal cross sectional view at 4c-4c in Figure 20 4b;

[032] Figure 5 is a top perspective view of another embodiment of a form panel unit;

[033] Figure 5a is a detailed perspective view of one of the several reinforcement units used in the form panel unit of Figure 5;

[034] Figure 5b is a fragmented transverse cross-sectional view of a form panel unit 25 of Figure 5 suspended from and sealingly suspended between a pair of supporting beam members;

[035] Figure 5c is a fragmented longitudinal cross sectional view at 5c-5c in Figure 5b;

[036] Figure 5d is a top perspective of a pair of supporting beam members in 30 isolation, as employed in the system of Figures 5b and 5c;

[037] Figure 6 is transverse cross-sectional view of an alternate embodiment of a form panel unit suspended between composite supporting beam members in an opening therebetween;

[038] Figure 6a is a fragmented longitudinal cross sectional view at 6a-6a in Figure 5 6;

[039] Figure 6b is a front elevation view of a channel member forming part of the composite beam member of Figure 6;

[040] Figure 6d is a top perspective of a pair of composite supporting beam members in isolation, as employed in the system of Figure 6 and 6a;

10 [041] Figure 6c is a fragmented transverse cross-sectional view of a floor system employing several of the form panel units of Figure 6 in a ceiling structure with several composite beam members embedded into the reinforced concrete floor slabs and connected with ceiling structures.

[042] Figure 7 is a transverse cross-sectional view of another embodiment of a system employing an alternate form panel unit suspended between composite beam members with an opening;

15 [043] Figure 7a is a fragmented longitudinal cross sectional view at 7a-7a in Figure 7; and,

[044] Figure 7b is a fragmented transverse cross-sectional view of a floor system employing several of the form panel units of Figure 7 in a ceiling structure with several composite beam members embedded into the reinforced concrete floor slabs and connected with ceiling structures;

[045] Figure 7c is a top perspective of a pair of composite supporting beam members in isolation, as employed in the system of Figure 7, 7a and 7b;

20 [046] Figure 8 is perspective view of a beam member in accordance with another embodiment of the invention;

[047] Figure 8a is a transverse cross-sectional view of another embodiment of a system employing an alternate form panel unit suspended between a pair of beam members of Figure 8;

25 [048] Figure 8b is a fragmented longitudinal cross sectional view at 8b-8b in Figure 8a;

[049] Figure 9 is perspective view of a beam member in accordance with another embodiment of the invention;

[050] Figure 9a is a transverse cross-sectional view of another embodiment of a system employing an alternate form panel unit suspended between two spaced composite U-beam members, each composite U-beam member formed from a pair of beam members in accordance with Figure 9, joined together in face to face relation;

5 [051] Figure 9b is a fragmented longitudinal cross sectional view at 9b-9b in Figure 9a; and

[052] Figure 10 is a top perspective view of part one of the U-shaped composite beam members used in the system of Figures 9a and 9b.

10 **[053] DETAILED DESCRIPTION**

[054] With reference to Figures 1 and 1a, a form panel unit 110 is illustrated and includes a perforated panel 112, which may in some embodiments be generally parallelepiped in shape. Panel 112 may be made from a foamed plastic, such as 15 polystyrene, type XPS or EPS having a density for example, of 1.2 to 2.0 pounds/feet³. Such polystyrene foam panels 112 are commercially available and often come in sizes as 2' x 8' or 4' x 8' and thickness of 2", 3" or 4". Although foam plastic panels are preferred, other type of materials can be used for the panels such as particle boards, oriented strength boards (OSB), plywood, cement-bonded particle boards and 20 etc.

[055] In some embodiments, panels 110, such as EPS panels, can be laminated with a polyethylene or polypropylene skin during manufacturing in order to decrease the thickness of the panels. Providing such a skin, laminated to both the upper surface 124, and lower surface 126 provides the panel with greater flexural strength, than an 25 unlaminated panel. By way of example, while an unlaminated panel of EPS would preferably by way of example, be about 100mm thick for an application, the laminated panel can be in the order of 50mm and still have the necessary performance characteristics. It should be noted that with XPS panels there is typically no need to 30 laminate the same on either upper or lower surfaces. Foam plastic panel 112 has a generally planar upper surface 124 and lower surface 126. Additionally, it has side surfaces 128 and 130 as well as opposed front and rear surfaces 132 and 134, all of

which are planar and are oriented generally orthogonal to their respective adjacent surfaces.

[056] With reference to Figures 1, 1a, 2 and 2a, it will be observed that form panel

5 units 110 also include a plurality of transversely spaced reinforcement units 122.

Reinforcement units 122 include horizontal reinforcement bar members 114, orthogonally positioned rod members 116 and a spacer rod member 118. Members 114, 116 and 118 are all welded or otherwise secured together as a composite structure to provide for a rigid structure. Preferably rod 118 and reinforcement bar

10 114 are substantially parallel to each other and vertical rod 116 is orthogonal to both rod 118 and reinforcement bar 114. Spot welding may be carried out to join the members together at all locations where the members cross each other. The panels may be perforated with appropriately spaced apertures prior to installation in the formwork to permit the vertical rods 116 to pass through the panels. It should be

15 recognized, however, that a seal of some kind should be provided (such as by a tight friction fit) to inhibit leakage of unhardened composite material. Perforations can be provided using conventional techniques and devices or with a device like or similar to that which is disclosed in US patent applications serial no. 10/253,843 filed September 24, 2003, and serial no. 10/307,855 filed December 2, 2002, the contents

20 of which are hereby incorporated herein by reference.

[057] Reinforcement bars 114 have hooked end portions 115 at either end which facilitates the positioning and securing of the form panel unit 110 when suspended on the upper face of the transverse flange portion 140a of beam members 140.

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[058] At the lower end of rod 116, a connector member 120 is provided which can engage and be secured to the downwardly extending end portion 116a of rod 116.

Connectors can be made from a suitable plastic material such as polypropylene or polyvinyl chloride. Connectors 120 have a shaft portion 120a, which includes a cylindrical cavity having an end opening which can engage a rod end portion 116a of rod 116. The cylindrical cavity will typically have a thread for engaging the end 116a of the rod. The end 116a may also have a tap end to form a threaded connection to the connector 120. The connector 120 can be drawn further along rod portion 116a

thus tightening the connection between connector 120, panel 112 and spacer rod 118.

The extension portion 120a will eventually engage spacer rod 118 thus preventing over tightening of the connector, which might damage the foam plastic panel 112.

However, it is desirable that panel 112 be firmly held, possibly under slight

5 compression, between the spacer bars 118 and their respective connectors 120 of each of the reinforcement units 122. Additionally, the spacer rod 118 ensures proper spacing of reinforcement bar members 114 from the inner surface of the panel 112 providing the required concrete protective layer, which is important in building concrete reinforced structures.

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[059] As shown in Figure 1, reinforcement units 122 are longitudinally spaced from each other along the length of panel 112 and this spacing can be approximately 8 inches for many applications, although the spacing can be selected to suit each application.

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[060] Vertical rods 116 can be by way of example, $\frac{1}{4}$ inch cross sectional diameter/width steel rods and transverse reinforcement bars 114 can be steel rods. Reinforcement bars 114 may typically have a ribbed surface, and can by way of example have cross sectional diameters or cross sectional widths of 8mm to 15mm, 20 although other configurations and materials, of course, are possible. Spacer bar 118 can be a steel rod having a diameter or width in the range of 2mm to 4mm.

[061] Finally, form panel unit 110 includes a longitudinally extending sealing members 138 which are mounted by conventional means such as with construction adhesives to side surfaces 128 and 130 near the upper surface 124 of panels 112. Sealing members 138 should extend the length of foam panel 112 and be of a suitable resilient sealer material, such as for example, an expanded rubber, sponge or other resilient materials commonly used for window and door sealing. Such resilient sealing members 138 can have a cross-sectional diameter or width in the range of $\frac{1}{4}$ 30 inch to $1\frac{1}{2}$ inches. Alternatively other sealing members or mechanisms can be employed.

[062] It will be appreciated that in this embodiment (like the other embodiments described hereafter) stretching longitudinally, a series of reinforcement units 122 including panels 112 can be mounted on and between each pair of beams 140 to provide for a longitudinally extending formwork of a series of panels. Transverse 5 panels edge faces that are adjacent each other in panels arranged in a longitudinal direction, can be held in abutment with each other to provide a suitable seal. Also, seals in the transverse direction, between such adjacent longitudinal panels can be provided, such as with construction expandable foam.

[063] It will also be appreciated that although not shown in the drawings conventional form techniques and materials can be used at the extreme side faces (both transverse and longitudinal) of the composite formwork provided by a series of panel units 110 arranged both longitudinally and transversely adjacent each other to restrain the unhardened composite material from flowing horizontally, thus providing 10 the slab with an appropriate depth of composite material.

[064] With particular reference now to Figures 2 and 2a, form panel units 110 are illustrated. A form panel unit 110 can be mounted between spaced support members 140. Support members 140 can themselves connected to or otherwise supported other 20 members of structures (not shown) such as by a structural wall, foundation wall, posts or other members or structures. In the example illustrated embodiment, and as shown in isolation in Figure 1d, support members 140 are steel beams having a generally channel shaped form and have relatively large transversely extending apertures 141 through the vertical web portions. Apertures 141 facilitate a lightening of the weight 25 of the steel beam, as well as to provide for passage therethrough of duct pipes, wiring or the like, have a series of spaced apertures. An example of a suitable beam member would be the Thermasteel™ beam manufactured by company Vicwest (Oakville, Ontario, www.vicwest.com). It should be noted, that steel and wooden flange beams, composite wooden I-beams, steel and wooden girders, etc. can be used as support 30 members.

[065] The standard beam members 140 are however modified to provide vertically extending apertures 180 that pass through the upper web portion 140a of each beam

140. Apertures 180 serve two principal functions (1) during the concrete pouring process, they inhibit the development of air pockets underneath web portion 140a of beams 140 (air pockets are undesirable in concrete) and (2) they assist in the anchoring of the beam member in the concrete slab once the concrete has hardened.

5 The size and spacing of the apertures 180 is selected such that the strength of the beam is not impaired to the extent it can't fulfill its supporting function. By way of example only circular apertures having a diameter of about 15-25mm on a web portion 140a 50mm in width, spaced apart at intervals of 80-120mm are acceptable for most applications where the length of the member does not exceed 12m.

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[066] As shown in Figures 2 and 2a, form panel units 110 can be mounted between beam members 140 by hooking end portions 115 of each of the members 114 along one side of the reinforcement units over the opposite side of the top surface of the web portion 140a of the longitudinally extending beam members 140. Then the form

15 panel unit 110 is moved generally horizontally such that the sealing member 138 comes into contact with and rests against a surface of an upper portion 140d of the vertical web, above and supported on upward facing flange portions 140c surrounding apertures 141 of beam member 140.

20 [067] As shown in Figure 2a, the other side of form panel unit 110 can thereafter be pivoted downward and the other sealing member 138b will be compressed along with sealing member 138a, such that a tight sealing fit formed between the edge surfaces 128, 130 and the adjacent surfaces of the portions 140d of beams 140. Thus panel units 110 can be easily mounted on a series of spaced, longitudinally extending beam members 140.

25 [068] As illustrated in Figure 2b, a connection between adjacent form units 110a and 110b is shown whereby reinforcement member 114a overlaps with reinforcement member 114b of form panel unit 110b. Also, as illustrated in Figure 2b, sealing elements 138b have been compressed between the edge surfaces 128, 130 and the adjacent surfaces of the beam member 140. In this way, seals are provided between the longitudinal edges of the form panels and the beam 140. It should be noted that at the longitudinal, transverse extending end surfaces 132 and 134 (see Figure 1),

suitable seals may be required to ensure a seal that will prevent the flow of unhardened concrete between longitudinally arranged, adjacent panels, when the concrete is poured into the form. The sides of the slab formwork can be provided by conventional techniques and materials (not shown).

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[069] Upward extensions 116e of the rod members 116 cooperate with reinforcement bar members 114a and 114b to provide location positions for longitudinal reinforcement bar members 142, which may be conventional reinforcement steel bars.

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[070] With reference now to Figure 3, part of a structural ceiling and floor structure 150 employing the form panel units 110, is shown. Ceiling structure 150 is formed with a concrete slab 152 reinforced with longitudinal reinforcement members 142 which are supported in the manner shown in Figures 2b and 2c by form panel units 110 which are partially obscured by the concrete material of concrete slab 152 in Figure 3. Beams 140 which in this example embodiment, have transverse openings 141 through their vertical web, are embedded into the reinforced concrete floor slabs above and connected with ceiling structures below. Schematically, the installed vent ducts and wiring with electric fixtures are shown.

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[071] The bottom flange web 140e of each of the beams 140 has a downward facing surface to which can be attached with conventional attachment devices such as screws, to a ceiling panel material 160, such as particleboard or drywall panel or other suitable ceiling panel.

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[072] Additionally, in the space between insulating foam panel 112 and ceiling panel 160, a space is provided which can be utilized for incorporating therein items such as duct work pipes 154 for air-conditioning, heating or the like, as well as electrical conduits such as electrical conduit 156 which can be interconnected to a light fixture 158 or other electrical device. If steel beams or joists with openings, such as Thermasteel™ (Canada), Dietrich TradeReady® (USA), Speedfloor (New Zealand), Komdecke™ (Chech Republic) and others are used, it is possible to install utilities

piping and wiring passing transversely through the openings 141 in the beams 140, without any significant reduction of the beams' load bearing capacity.

[073] It should be noted that, once the concrete has been poured into the form, part 5 of which is provided by the panels 112 at the bottom, and by other conventional form work at the sides (not shown), the upper web portion including transverse upper flange 140a in each of the beams 140 is embedded within the concrete slab 152. One of the benefits of such an arrangement is that, in the case of a fire, the beam member 10 140 will tend to be held in place in the concrete, which will hold up the ceiling panels 160. Concrete that has flowed through apertures 180 assists in anchoring the beams 140 into the concrete slab. This will inhibit or completely prevent the plastic material from which foam panel 112 is made, if melted due to the heat, from falling down into the space beneath the ceiling structure and possibly injuring people in the room space below.

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[074] It will also be appreciated that in addition to the longitudinal reinforcement bar members 142, the horizontal reinforcement members 114 having served one of their functions in supporting the panel 112 which acts as a concrete form, once the concrete has hardened, also serves the function of providing transverse reinforcement for the 20 slab 152.

[075] It will be appreciated that concrete structures employing the form panel unit and beams of the present invention can be implemented and fabricated in different environments or situations.

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[076] For example, form panel units 110 can be pre-constructed at a manufacturing facility and shipped to a construction site. At the construction site, they can be mounted to beam members 140 which would be supported in conventional ways such as by structural support walls, other beam members or the like. Alternatively, pre-fabricated structural concrete slabs can be pre-fabricated at a manufacturing plant off-site, utilizing a beam arrangement supporting form panel units to form a pre-fabricated concrete panel structure. The pre-fabricated concrete slab can then be shipped to a construction site for installation in a particular application, including as a 30

wall, floor or ceiling structure. It will therefore appreciated that if pre-fabricated in horizontal orientation at an off-site separate manufacturing facility, when shipped to a building site for installation, it is not necessary that the concrete slab structure be used in the actual building structure in a generally horizontal configuration.

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[077] With reference now to Figures 4, 4a and 4b, another embodiment of a form panel unit can be used in combination with structural support members to produce a structural concrete slab is illustrated. Form panel unit 210 includes a foam plastic panel 212, as described above and includes a plurality of longitudinally spaced 10 generally transversely oriented reinforcement units 222.

[078] As particularly shown in Figure 4a, the reinforcement units 222 include reinforcement bar members 214, vertical rod members 216 and connectors 220. However, instead of a spacer rod as described above, spacer flange members 218 are 15 provided. As specifically shown in Figure 4b, flange members 218 have a flange 218e and a shaft portion 218f having an end 218d. Shaft portion 218f and head portion 218e are mounted preferably for slidable movement on a portion of rod 216. Rod 216 also passes into a shaft portion 220a to connector 220, in a manner previously described in relation to connector 120. The end 220d of connector shaft 20 portion 220a is also configured to engage head portion 218e of flange 218, when connector 220 is tightened on rod 216. In this way, as connector 220 is tightened drawing the panel material 212 towards the reinforcement member 214, end 218d of shaft 218f will come into abutment with the reinforcement member 214, and connector end 220d will contact flange head 218e. In this way, the panel material 212 25 can be compressed to some degree between flange head 218e and the head of connector 220. This ensures a rigid or semi-rigid connection between form panel units 222 and panel 212 and also ensures proper spacing of reinforcement bar members 214 from the inner surface 224 of the panel 212.

30 [079] It will also be noted that reinforcement bar members 214 do not have hooked ends and when installed as shown in Figure 4b on beams 240 reinforcement bars 214 of one form panel unit, do overlap as in the previous embodiment with its bars 114, with reinforcement bar members 214 of an adjacent form panel unit 210.

[080] As shown, the sealing mechanism between adjacent form panel units 210 and the supporting members, is different than in the previous embodiment. In this embodiment, the side surfaces 228 and 230 of the panels 212 have sloped portions 229 and 231, respectively. These two panels are brought into generally abutting relation on either side of a beam member 240. Thereafter, an expandable foam can be injected or otherwise placed into the generally V-shaped channel formed with each arm of the V-shaped channel positioned on either side of the central web of beam 240. An example of a suitable expandable foam is a standard foam of the type used for sealing windows or doors. It would be appreciated that this mechanism and system 10 can be utilized when a thicker foam panel 212 is required for extra insulation value.

[081] With reference now to Figures 5 and 5a, another embodiment is illustrated in which the form panel unit 310 includes a panel member 312 comprising particle boards, oriented strength boards (OSB), plywood, cement-bonded particle boards (CBPB) and the like and which may in some embodiments have a thickness of 15 between 5/16 inch to 1 inch.

[082] Each of the reinforcement unit 322 that are mounted to the panel unit 312 includes a pair of longitudinally spaced reinforcement bar members 314 and 315, each being welded to or otherwise secured to the underside of a top plate 317e of a U-bracket 317. A pair of U-brackets, which can be made from a metal such as for example, steel or aluminum, and transversely spaced are provided for and secured to the reinforcement bars 314, 315 in each reinforcement unit 322. Of course, it is not 25 necessary that it be a U-shaped bracket or that there be two reinforcement bar members, however the reinforcement members 314, 315 should be spaced from the upper surface 324 of panel 312. The U-brackets can be secured to the upper face 324 of the panel 312 using conventional attachment devices such as plywood, particle board self-threaded screws or the like 325. Adjacent to the longitudinally extending 30 side edges 328 and 330 and mounted on upper surface 324 and extending past the side edges 328 are rubber strips 338 providing seals as described above. The rubber strips are made of a suitable resilient rubber such as the kind of rubber material used for door and gates sealing.

[083] As shown in Figures 5b, 5c and 5d, the supporting beam members 340 which may be Dietrich TradeReady® steel joists (Dietrich Metal Framing, 500 Grant Street, Suite 2226, Pittsburgh, PA, 15219, USA) have transverse apertures 341 passing through the vertical web portions. Beams 340 are generally C-shaped channel, beam members, and in this embodiment as in the previous embodiments, are oriented in the same (face to back) direction. Beams 340 also have apertures 380 which function like apertures 180 in beams 140, as described above. Form panel units 310 may be mounted onto beams 340 in a manner similar to that shown in Figure 2 and 2a with respect to form panel units 110 and in Figure 4 and 4a with respect to form panel units 210.

[084] It will be noted that sealing strips 338 are displaced and due to their resiliency will exert a force against the web surface of the upper web portion 340d of the beam 15 340, thus providing a seal between the panel 312 and the beam members 340. This provides a suitable part of a form for the placement of unhardened concrete to form a concrete slab (not shown).

[085] Now with reference to Figures 6, 6a and 6b, another embodiment is illustrated. 20 In this embodiment, form panel unit 410 comprises an upper foam plastic panel 412 and a lower foam plastic panel 413. Panels 412 and 413 are generally in spaced longitudinal and transverse parallel alignment.

[086] Panels 412 and 413 are rigidly held in such space relation by reinforcement 25 units 422. Reinforcement units each comprise rod members 416 having at one end, connectors 421 secured and attached thereto and at the other end, connectors 420 attached thereto. Connectors 421 and 420 can be like connectors 120 but connect to rods 416 at each end in the same manner. Panel 413 is held in slight compression between spacer bar 418 which is rigidly interconnected and secured to rods 416 and 30 connectors 420. Likewise panel 412 is held in slight compression between connectors 421 and spacer rod 419. Positioned in vertically spaced relation to both panel 412 and rod 419 on the one hand and spacer rod 418 and panel 413 on the other, is central transverse reinforcement bar member 414. Thus, the combination of panels 412, 413

and several longitudinally spaced, reinforcement units 422 (in transverse parallel relation), comprise a rigid unit which is suitable for being mounted and suspended on composite beam members 420.

5 [087] As shown in Figure 6d, composite beam members 420 each include a pair of generally C-shaped channel beams 425, 427 oriented in face-to-face relation and interconnected to each other by a generally U-shaped longitudinally extending channel member 423 which can be made for example from tin with gauge 18 or other suitable materials, and which interconnects to an upper web portion of each of beams
10 427 and 425 by structural connectors such as self-threaded screws. Each of beams 425 and 427 has aligned transverse apertures 441, like apertures 141, to permit the passage of ducts and wiring and the like. Also, each of beams 425, 427 has vertically opening apertures 480 which function like apertures 180 as described above.

15 [088] The transverse width of panel 413 is selected to produce a tight compression fit against the upper web portion of a beam 425 of one of a pair of spaced composite beams 420 and against the upper web portion of a beam 427 of the other of the pair of spaced composite beams 420, as shown. In this embodiment, the panel unit 410 can simply be lowered more or less straight vertically down, with the panel 413 being
20 pressure fit between beams 420. In the embodiment shown, no additional sealing mechanism or device is provided between the panel 413 and the beam members. If desired, however, sealing mechanisms between panel 413 and the surfaces of the beams 427, 427 could also be provided.

25 [089] The form panel unit 422 is mounted onto upper transversely extending web portions 425e and 427e of beam members 425 and 427 respectively. It will be noted that reinforcement bars 414 each have hooks at their ends to facilitate a connection with the flange portions 425e and 427e of the beam members. In this embodiment, concrete is poured into the space between panels 412 and 413 to provide a structural
30 concrete slab as shown in Figure 6c. Additionally, below panel 413, as shown in Figure 6c, space is provided between a sealing panel 460 and the lower surface of foam panel 412 for duct work 454 and electrical conduits 456 and the like, similar to as described above. The apertures 441 in the beam members 440 allow passage of

such items. Structural slab 452 thus is provided once the concrete has hardened and has insulation from panels 412 and 413 on both sides. Additionally, longitudinal reinforcement members 442 can be provided for longitudinal strengthening of the 5 slab. Such members 442 could be placed between panels 412, 413 prior to the concrete pour and can be positioned to rest on horizontal members 414.

[090] With reference to Figures 7, 7a and 7b a form panel unit 510 is constructed similar to form panel 110 as described above each having a panel 512 and one or more reinforcement units 522. Each reinforcement unit has at least one reinforcement 10 bar 514, vertical rod 516 joined thereto and connectors 520. However, foam plastic panel 512 is suspended from the lower web 540e at each end by ends of reinforcement bar 514. Beam members 540 are composite I-beams formed from a pair of generally C-shaped channel beam members structurally secured to each other in back-to-back relationship. As shown in Figure 7c, each composite beam member 540 is formed 15 with two back to back channel members 545 joined in back to back relation by conventional mechanisms such as by way of example, welding, structural bolts etc. Each channel beam 545 is constructed like beam members 140 described above. For the purpose of installation of the formwork panel unit 510, the positioning of panel 512 in relation to the reinforcement member 514 (and thus the beams 540) is such that 20 panel 512 has one side that extends beyond the center of the joined channel beams. The other side is the same distance short from the center of the joined channel beams of the adjacent support member 540. The formwork units 510 are suspended from the bottom webs 540e by inserting one end of the reinforcement bars 514 into the cavity between beams 540 and afterwards the opposite end of the reinforcement bars 514 is 25 inserted in the same cavity. Afterwards, the ends of the reinforced bar 514 are lowered to the flanges 540f and 540e by lowering one side edge onto flange 540e and then rotating the opposite side edge of the panel relative to the other edge of the panel 510 in a manner similar to the rotation of the reinforcement units 122 and panel 112 in 30 Figures 2a.

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[091] As shown in Figure 7b, form panel unit 510 is utilized in the construction of a concrete reinforced floor slab 552 which includes a floor panel material 560 such as by way of example, plywood which is supported on and secured to the upper web

surfaces 540f of beams 540. Also the floor construction incorporates duct work pipe 544 and electrical conduit 556. The panels 512 of transversely adjacent panel units 510 are shown to be in abutment with each other to provide for thermal and acoustic insulation. Additionally, ceiling panel 561 is secured beneath panel 512 by anchor screws attached to the concrete reinforced floor slab 552 through panel 512 or attached by self-threaded screws to connectors 520 installed in panel 512. Ceiling panel 561 may by way of example be made of materials such as drywall, gypsum plates, cement board, cement bonded particle boards etc. It should also be noted that in this embodiment, slab 552 includes longitudinal reinforcement members 542.

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[092] With reference now to Figure 8, a support member 640 which can function as a beam, joist or other support member, is shown. Beam 640 can be made of known beam materials, such as for example, steel, aluminum and certain composite materials. Beam 640 is generally configured to be used in an inverted L-shape having a vertical web 640a and a transverse short leg portion 640f. Transversely formed through web 640a are apertures 641 which are suitable for receiving therethrough ductwork, electrical conduits or the like. Additionally, in a lower portion of web 640a are apertures 690 and T-shaped apertures 691 positioned in spaced relation longitudinally along the web 640a.

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[093] As shown in Figures 8a and 8b, a pair of spaced beams 640 support a panel unit 610 having a plurality of reinforcement units 622 which are constructed in a manner similar to the panel units described above. Panel units 610 are shown in abutting relation to provide a form for a floor/ceiling slab structure, similar those described above. Reinforcement member 614 of each panel unit 610 has upturned end hook portions at each end. As shown in Figure 8b, the reinforcement unit 622 of each panel unit 610 can be mounted and suspended from beams 640 (which are preferably oriented in face-to-back relation but can be in face to face relation) by moving the reinforcement units 622 of a panel unit 610 from below upwards and then inserting the horizontal portions of members 614 adjacent the apertures 691, vertically upwards in trunk portion 691x of aperture 691, and then moving the member 614 transversely into a leg portion 691y. This movement will put the members 614 into a position whereby panel unit 610 can be suspended from the beams 640. The hooked

portion 614a, 614b, of each of the members 614 prevent any significant transverse displacement of panel unit 610 and to some extent lock the members 614 in an appropriate formwork position. Additionally, it will be observed from Figure 8b, that one end portion 614a of one members 614 of one reinforcement unit 622, and
5 opposite end portion 614b of a member of another reinforcement unit 622, can fit into opposite leg portions 691y of the same aperture 691.

[094] When the concrete is poured into the form of Figure 8b, concrete will abut the lower portion of web 640a and will flow into apertures 690 and the remaining vacant
10 space in apertures 691. Concrete flowing into apertures 690 in particular will provide , once the concrete has hardened, anchors for the beams 640. This will serve to help support the panel units including panel 612, including during any fire.

[095] With reference now to Figure 9, a support member 740 which can also
15 function as a beam, is shown. Beam 740 can, like the other support members described herein be made of normal beam materials, such as for example, steel, aluminum and certain composite materials. Beam 740 is generally configured to be used in an L-shape having a vertical web 740a and a transverse short lower leg portion 740f and an upper edge 740e on central web 740a. Transversely formed
20 through web 740a are apertures 741 which are suitable for receiving therethrough ductwork, electrical conduits or the like. Apertures 741 have flanges 742 with upper flange surfaces 741a. Additionally, in an upper portion of web 740a are apertures 790 positioned in spaced relation longitudinally along the upper portion of the web 740a.

25 [096] As shown in Figures 9a and 9b, a pair of composite beams 780 is shown each comprising a pair of beam members 740 joined together by welding or other known connection devices or methods, in face to face relation. Each composite beam 780 supports one side of a panel unit 710 on reinforcement units 722. Thus, a panel unit 710, comprising a panel 712 and at least one reinforcement unit, is supported on each
30 side by a beam member 740 of a composite beam 780. Each panel unit 710 will be in most but not all embodiments, be supported by at least two, spaced, transversely oriented reinforcement units 722.

[097] A panel 712 of a panel has side surfaces in abutting relation to the upper portion of webs 740a of a pair of spaced beam members 740, 740 that are in back to back relation. The side surfaces engage the vertical web beneath apertures 790.

5 **[098]** It will be noted from Figure 9b that the upper surface 724 of panel 712 is positioned below the lower edges of apertures 790 in each beam member 740. The panel units 710 provide part of a form for a floor/ceiling slab structure, similar to those described above.

10 **[099]** With reference to the reinforcement units, which are constructed in a manner similar to the units described above, reinforcement members 714 each have down-turned end hooks portions 714a, 714b at each end. End portions 714a, 714b hook over the upper edges 740e of their respective beams 740. Compressive forces are imparted on the upper portions of webs 740a and the friction between the hook portion and the 15 web of the beam will also resist any tendency for the member 714 to move upwards off the supporting beam webs 740a. As shown in Figure 9a, the hook portions have a portion that curves outward and then inward and are configured to provide a spring-like effect. Accordingly, when end portions of members 714 are attached as shown, each of the reinforcement units 722, will be relatively securely mounted and 20 suspended from beams 740. In this embodiment, a pair of beams is arranged face to face relation at each junction of reinforcement units 722.

25 **[0100]** A separate panel portion 1712, typically of the same material as panel 712 (which like the other panel members will be like those panels described above) is friction fit between the inward facing surfaces of beam members 740, and are positioned in alignment with adjacent panel members 712. Additionally, panel portions 1712 can be supported on the upper flange surfaces 741a.

30 **[0101]** When the concrete is poured into the form of Figure 9a and 9b, concrete will abut the upper portion of web 740a at the level of upper surface 724 or panel 712; Concrete will flow into apertures 790 and will provide , once the concrete has hardened, anchors for the beams 740. This will serve to help support the reinforcement unit 722 including panel 712, including during any fire.

[0102] Additionally vertical rods 716 which are joined to connectors 720 at their lower ends, combine with ancillary vertical rods 796 which are welded to member 714 to provide cells each for assisting in holding one or more longitudinal reinforcement members 742.

[0103] Finally, with reference to Figure 10, a generally U-shaped, integrally formed beam member 840 is shown. Beam member 840 can be used, for example, instead of composite beam 780, in the system illustrated in Figures 9a and 9b. Beam 840 has a base web plate 840f from which are upstanding side webs 840a. Side webs have large central apertures 841 surrounded at their edges by inwardly directed flanges 841c having an upper surface 841a. Apertures 841 can be used in the same manner as described above, such as with apertures 141. Positioned below a top edge 840e of each side web 840a are a plurality of spaced apertures 890 which can be used to assist in anchoring the beam in a concrete slab.

[0104] Although the above embodiments have been described in connection with use with concrete, other similar construction materials which can be formed and harden in a construction form, can be used.

[0105] It is understood that the above-described embodiments are illustrative of only a few of the many possible specific embodiments of the invention. Numerous and varied other arrangements can be made by those skilled in the art without departing from the spirit and scope of the invention, as defined only by the claims herein.